

Report on Core Experiment CE02: 7-tap/5-tap Filter Bank Option

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August 2000

WG1 document number WG1N1844

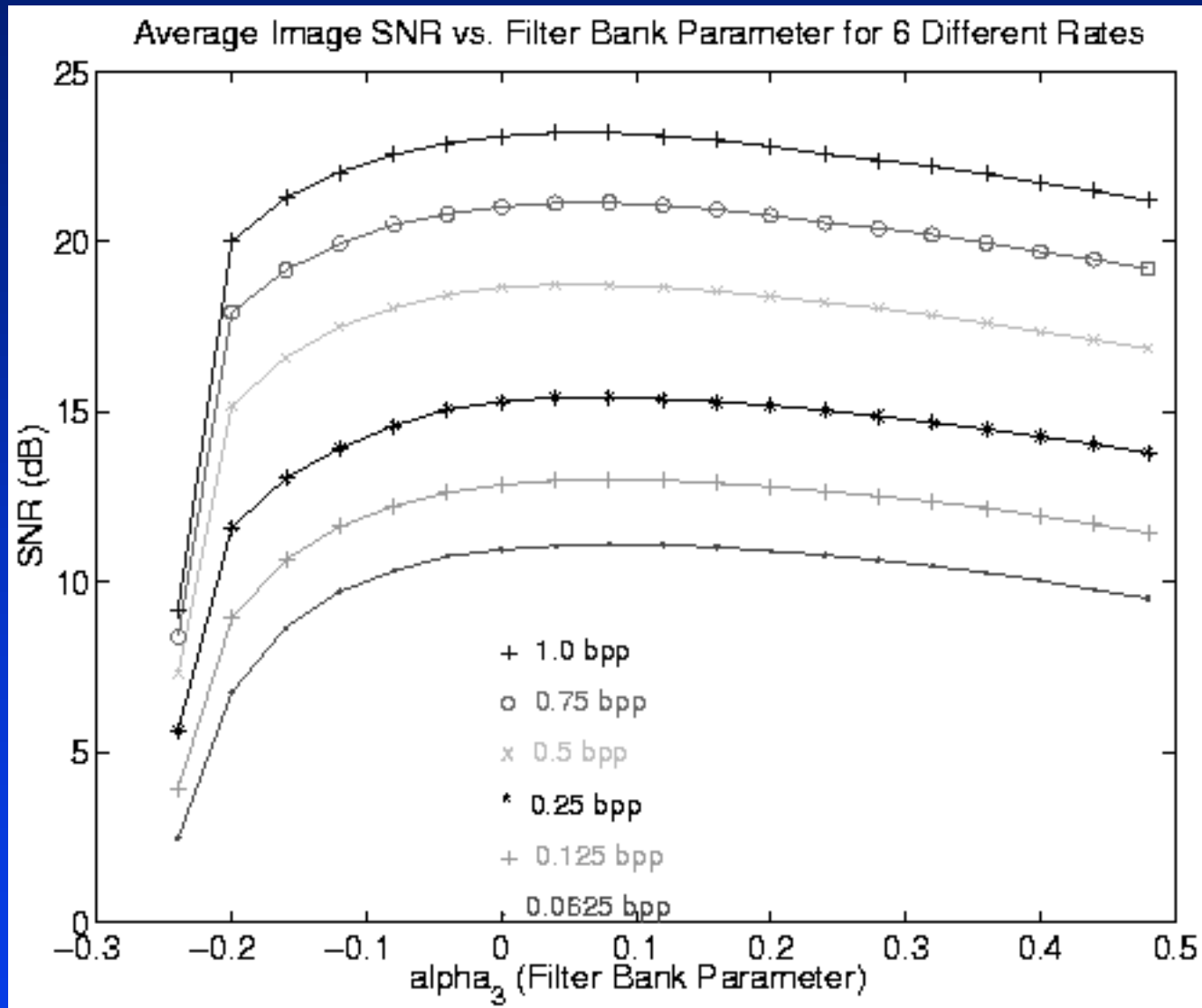
Goal of Experiment

- Develop a 7-tap/5-tap wavelet filter bank whose performance falls between that of the 9-7 and (irreversible) 5-3 baseline filter banks, both in terms of rate-distortion performance and in terms of implementation complexity.
- Include this 7-5 filter bank in Part 2 Annex F as an example of a user-specified optional filter bank.
- This would provide an alternative that “fills the gap” between the performance and complexity of the 2 baseline filters.

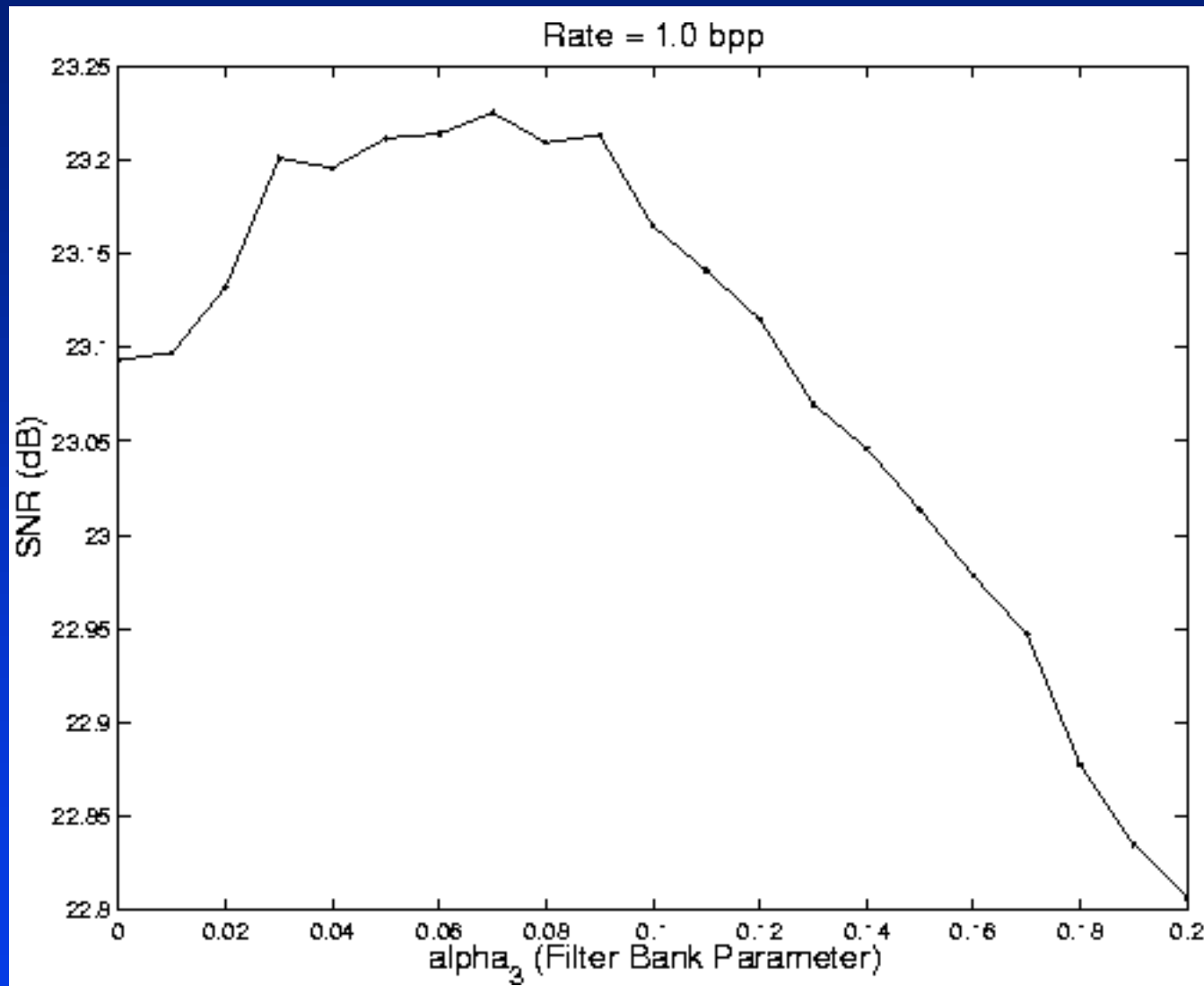
Engineering Approach

- Utilize a dense parameterization of odd-length filter bank categories developed by Brislawn and Treiber to design a filter bank customized for JPEG image coding and optimized over the entire 7-5 category.
- With imposition of requirement for 2 vanishing moments, the parameterization is 1-dimensional, allowing easy visualization of SNR landscapes with respect to the one degree of freedom (α_3).
- It has been proven that square-integrable solution do not exist for parameter values outside the interval $[-2, 2]$, reducing the landscape to a manageable size.
- Reconstructed image SNR averaged over 12 JPEG test images at 6 rates from 1.0 bpp down to 0.0625 bpp for 19 filter banks.
- Parameter value $\alpha_3 = 0$ corresponds to the natural embedding of the 5-3 (irreversible) filter bank in the 7-5 category.

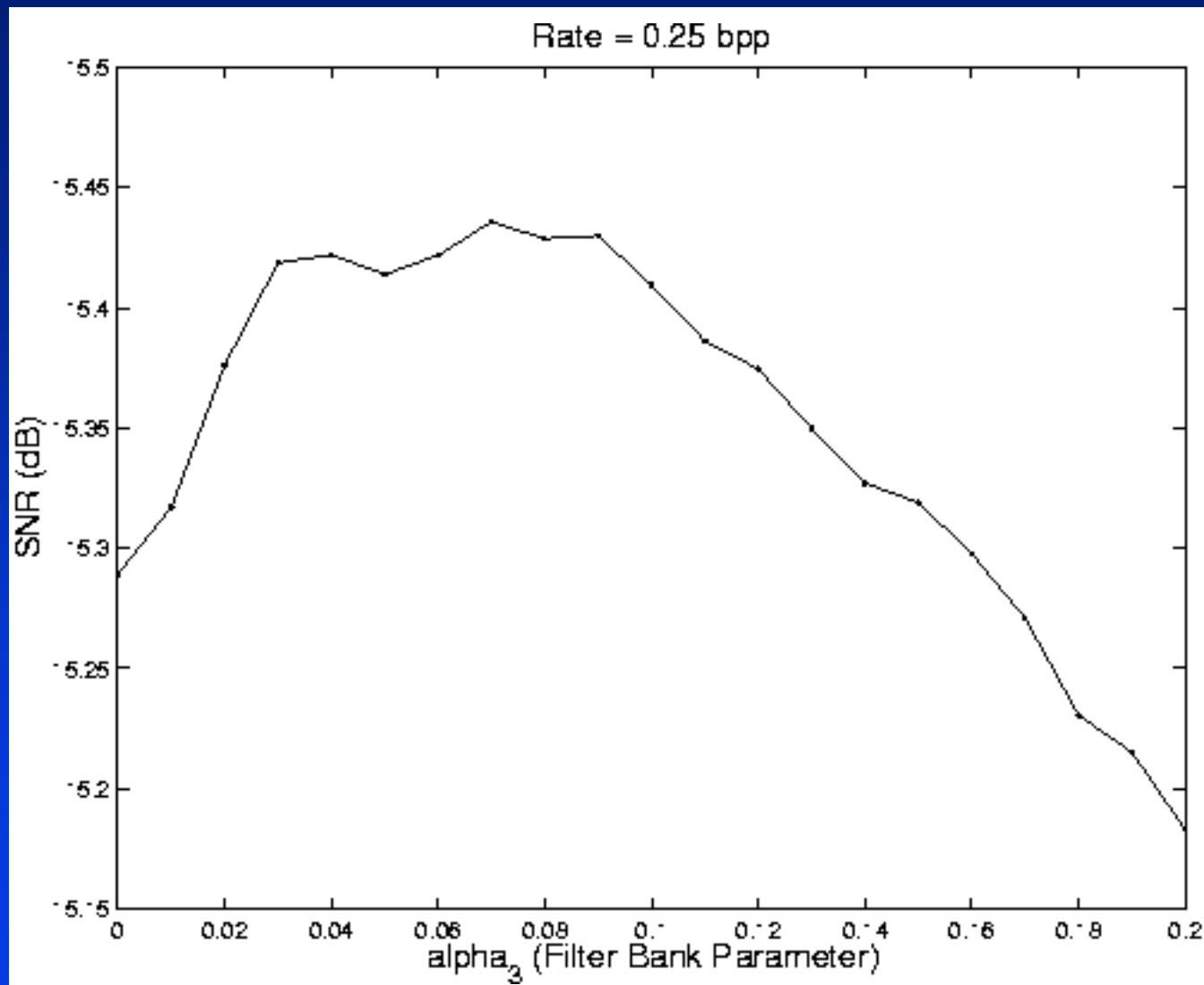
SNR Landscape for 7-5 Filter Banks



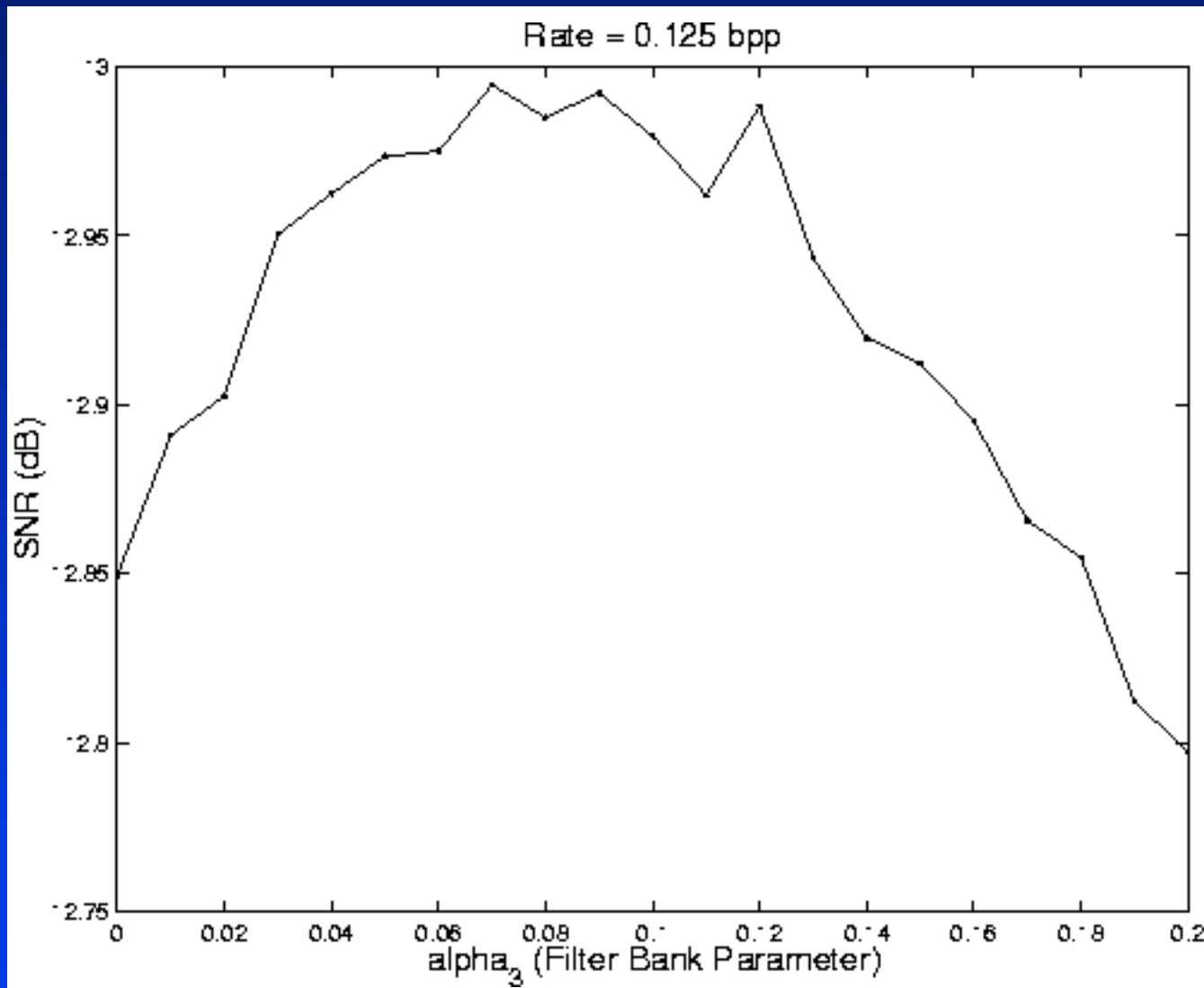
Detail of SNR Landscape near Performance Peak, 21 Different 7-5 Filter Banks at 1.0 bpp



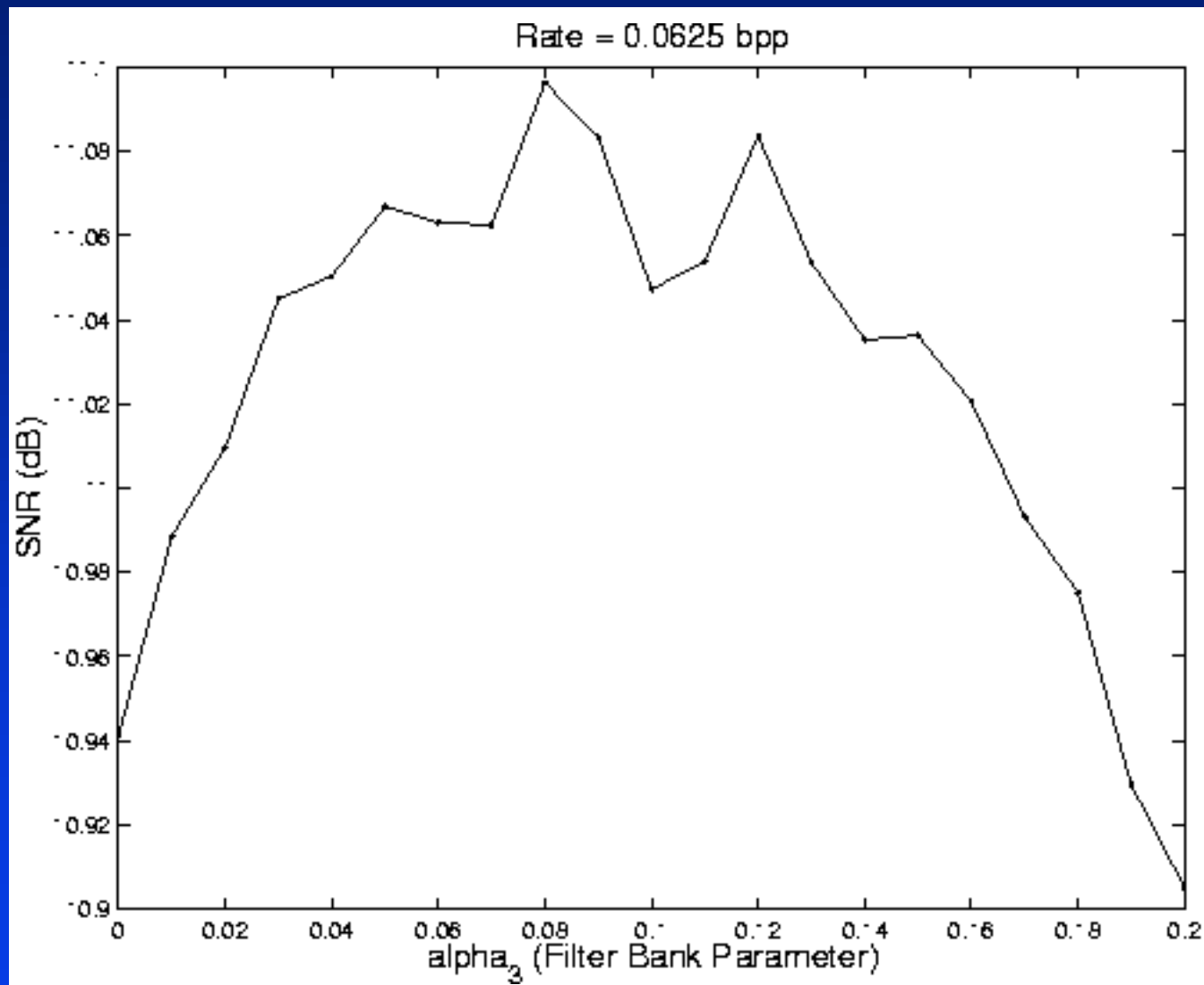
Detail of SNR Landscape at 0.25 bpp



Detail of SNR Landscape at 0.125 bpp: Note Peak Shift to Larger α_3 Values



Detail of SNR Landscape at 0.0625 bpp



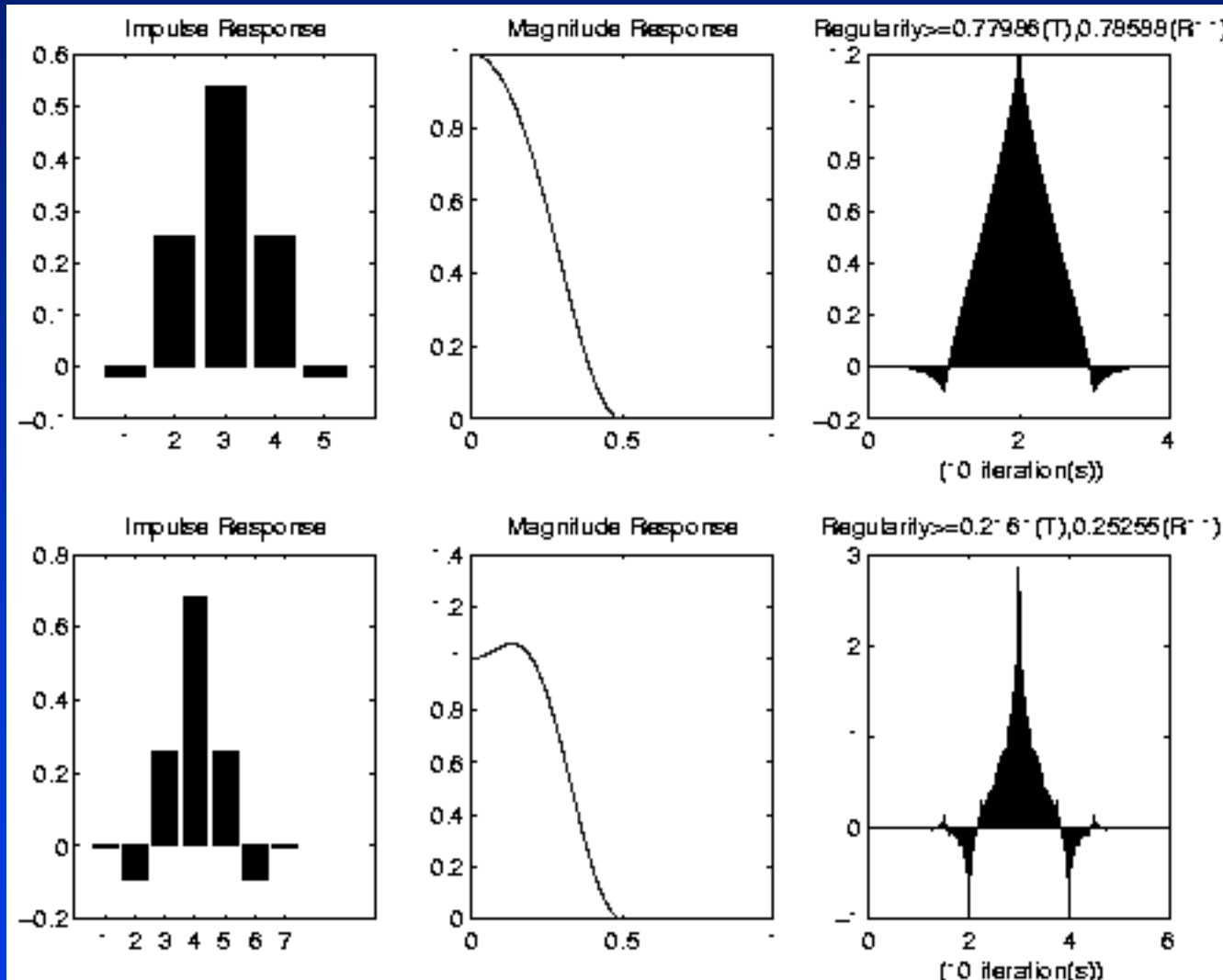
Optimal Parameter Value: $\alpha_3 = 0.08$

- We settled on $\alpha_3 = 0.08$ as a value providing near-optimal image coding performance from 1.0 bpp down to 0.0625 bpp.
- Improvements over 5-3 filter bank ($\alpha_3 = 0$) of about 0.11 dB SNR at 1.0 bpp to about 0.15 dB SNR at 0.0625 bpp.
- All impulse responses and lifting parameters are rational numbers:

n	$h_0(n)$ (analysis)	$f_0(n)$ (synthesis)
0	79/116	27/50
± 1	373/1450	1/4
± 2	-21/232	-1/50
± 3	-21/2900	

α	2/25
β	-175/406
γ	609/2500
K	25/29

Analysis, Synthesis Scaling Functions, $\alpha_3 = 0.08$



Summary and Recommendations

- We have designed a 7-tap/5-tap filter bank that is globally optimal for image coding performance in the 7-5 category.
- It provides an alternative to the 9-7 and irreversible 5-3 with intermediate rate-distortion performance and intermediate complexity.
- We recommend:
 - * Including the filter bank described in this Core Experiment report in Part 2 Annex F.4 as an example of an optional JPEG filter bank.
 - * Adding a kernel file for this filter bank to the VM distribution.